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(54) **Method for measuring splice loss of an optical fiber.**

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Description

The present invention relates to a method for estimating a splice loss of a spliced section of a fusion-spliced optical fiber.

Conventionally, the splice loss of a spliced section of an optical fiber is measured by a power monitor method. According to this method, light is permitted to pass through the optical fiber via the spliced section and the splice loss of the spliced section is measured from the amount of light received.

Due to the necessity to permit light to pass through an optical fiber, however, the power monitor method has a low operability. In this respect, therefore, an outline monitor method has recently been used frequently for its higher operability. (D. Marcuse "loss Analysis of Single Mode Fiber Splices", BSTJ, Vol. 56, No. 5, 1977; Satoru Yamazaki et al. "Simple Splicing Method for Single Mode Optical Fiber", National Conversation Record No. 2108, 1987, The Institute of Electronics Information And Communication Engineers; Akihiko Ishikura et al. "Splice Loss Factor Analysis for Subscriber Single-Mode Fibers", National Conversation Record No. 2100, 1987, The Institute of Electronics Information And Communication Engineers; Atsushi Ide et al. "Loss Assurance Method for SM-Fiber Mass-Splice Using Image Measurement" National Conversation Record NO. 2101, 1987, The Institute of Electronics Information And Communication Engineers). According to the second method, light is irradiated on the spliced section from two directions, X and Y, normal to each other to pick up an X image and a Y image of the outline of the spliced section, and the splice loss is acquired from the X and Y images. According to the conventional method for measuring a splice loss by monitoring the outline of a spliced section, however, a splice loss originated from opposite-phase core distortion cannot precisely be measured although a splice loss caused by axial deviation or angular deviation can be measured with a certain accuracy.

Accordingly, it is an object of this invention to provide a method for estimating a splice loss of an optical fiber, which method can measure a splice loss originated from opposite-phase core distortion.

It is also advantageous according to the invention to provide a splice loss estimating method for an optical fiber, which can measure, with a high accuracy, the entire splice loss including a splice loss originated from axial deviation or the one originated from angular deviation.

This object is solved in accordance with the present invention by a method including the features of claim 1.

Here the term "immediately after heating a pair of optical fibers" indicates the time period from a point when the heat treatment has starter to a point when, even if glass melts by the heat treatment, the surface tension of the melted glass has not yet worked sufficiently; the period is about 2 sec or less from the point when the heat treatment has started in the ordinary case involving spark heating. The term "prior to heating ..." means the time before the heat treatment has started or the time at which heat treatment has not started yet.

This invention can be more fully understood from the following detailed description when taken in conjunction with the accompanying drawings, in which:

Figs. 1A through 1D are diagrams illustrating optical fibers having defective fusion-spliced portions of various types;

Figs. 2A and 2B are diagrams each illustrating an optical fiber having a defective fusion-spliced portion with opposite-phase core distortion;

Fig. 3 is a histogram illustrating the relation between the amount of core distortion and splice loss;

Fig. 4 is a graph illustrating the relation between the cleaved angle of an optical fiber end and the splice loss - estimated loss;

Fig. 5 is a histogram illustrating the relation between the number and the splice loss of a spliced portion provided by fusion-spliced optical fibers having splicing ends cleaved by the proper cutter;

Fig. 6 is a histogram illustrating the relation between the number and the estimated error of the spliced portion provided by fusion-spliced optical fibers having splicing ends cleaved by the proper cutter;

Fig. 7 is a graph illustrating the relation between the estimated loss and splice loss of the spliced portion provided by fusion-spliced optical fibers having splicing ends cleaved by the proper cutter;

Fig. 8 is a histogram illustrating the relation between the number and the splice loss of a spliced portion provided by fusion-spliced optical fibers having splicing ends cleaved by an unadjusted cutter;

Fig. 9 is a histogram illustrating the relation between the number and the estimated error of the spliced portion provided by fusion-spliced optical fibers having splicing ends cleaved by the unadjusted cutter;

Fig. 10 is a graph illustrating the relation between the estimated loss and splice loss of the spliced portion provided by fusion-spliced optical fibers having splicing ends cleaved by the unadjusted cutter;

Fig. 11 shows a pair of ribbon type optical fibers to be fusion-spliced;

Fig. 12 shows an apparatus for fusion-splicing a pair of ribbon type optical fibers;

Fig. 13 shows a reflecting mirror onto which illuminating lights are directed; and

Fig. 14 shows an apparatus for fusion-splicing a pair of single type optical fibers. The followings are possible

major causes of a splice loss:

(1) Deviation of axes of optical fibers to be fusion-spliced (axial deviation).

(2) Angular deviation of optical fibers to be fusion-spliced.

(3) Opposite-phase core distortion between optical fibers as caused by the fusion-splicing.

(4) In-phase core distortion between optical fibers as caused by the fusion-splicing.

The axial deviation means a deviation of axes of fibers 1_1 and 1_2, i.e. a deviation of outer configurations of fibers 1_1 and 1_2, which is caused by fusion-splicing optical fibers 1_1 and 1_2 with their axes deviating from each other, as shown in Fig. 1A. Such an axial deviation occurs if the axes of the optical fibers 1_1 and 1_2, when butted against each other, are not aligned and heating is not sufficient.

Given that D2 is an amount of axial deviation and W is a spot size, the splice loss as is given by:

$$\alpha_1 = 4.34 \times (D2/W)2.$$

The angular deviation is caused by misalignment of ends of the optical fibers 1_1 and 1_2 and an excess amount of mutual pressing of these optical fibers, as shown in Fig. 1B. Given that θ is a deviation angle, n_2 is a refractive index of fiber core 2_1 and fiber core 22, λ is the wavelength of light and W is the spot size, the splice loss α_2 originated from the angular deviation is given by:

$$\alpha_2 = 10 \log [\exp \{-(\pi^2 n_2 W/180\lambda)^2 \theta^2).$$

With h = 1.3 μm, W = 5 μm and n_2 = 1.46,

$$\alpha_2 = 4.34 \times 0.0948 \times \theta^2.$$

The opposite-phase core distortion is a bending of the cores 2_1 and 2_2 in the opposite direction at the spliced portion as shown in Fig. 1C, and it is caused if the axes of the optical fibers 1_1 and 1_2 when butted are misaligned and sufficient heat is applied to the fibers under this condition. More specifically, when the optical fibers 1_1 and 1_2 having their axes misaligned, are heated in this state to a certain degree, a step would be formed at the exterior of the spliced portion as shown in Fig. 2A. If heat is further applied, the step portion would disappear due to the surface tension. At this time, the cores 2_1 and 2_2 are bent at the spliced portion as shown in Fig. 2B.

The in-phase core distortion is the bending of the cores 2_1 and 2_2 in the same direction at the spliced portion as shown in Fig. 1D. This distortion is caused by misalignment of the cleaved angles of fiber ends to be spliced and an insufficient amount of the optical fibers pressed. In other words, if the misalignment of the cleaved angles of the fiber ends is significant or the amount of the fibers pressed is insufficient to thereby form a neck portion or a small-diameter portion at the spliced portion, the fibers melt when heated and flow in the neck portion, thus bending the cores 2_1 and 2_2.

As described above, the opposite-phase core distortion occurs in the process as shown in Figs. 2A and 2B. With this in mind, the amount of deviation is measured before or immediately after the heat treatment, and the amount of deviation is again measured upon completion of the heat treatment, and the difference Y between these deviation amounts is then acquired. This difference Y is the amount of core distortion. And the amount Y can be considered to be index for measuring the splice loss.

To confirm this, we measured splice losses at many spliced portions by the power monitor method in order to find the relation between the core distortion amount Y and the splice loss caused by the core distortion. The acquired data includes the entire splice loss originated from axial deviation, opposite-phase core distortion and in-phase core distortion. Since the in-phase core distortion significantly increases the splice loss, however, measuring the entire splice loss including the one caused by this deviation should undesirably reduce the measuring accuracy. In this respect, therefore, data acquired from the spliced section at which the in-phase deviation occurred was eliminated. Accordingly, the entire splice loss in this case is the sum of the splice losses caused by the axial deviation, angular deviation and opposite-phase core distortion, and the measured splice loss data represents the splice loss including these three types of splice losses.

Since the splice losses originated by the axial deviation and angular deviation can be calculated as described above, the splice loss caused by the opposite-phase core distortion can be attained by subtracting these two splice losses from the actually acquired data. Fig. 3 illustrates the relation between the splice loss originated from the opposite-phase core distortion and the amount of the core distortion. With the regression linear line attained from this relation, the splice loss α_3 with respect to the core distortion amount Y can be calculated as follows:

$$\alpha_3 = 0.01484Y.$$

Since total splice loss is the sum of the splice loss α_1 originated from the axial deviation, the splice loss α_2 originated from the angular deviation and the splice loss α_3 originated from the opposite-phase core distortion, the total splice loss α can be measured by adding up the individually calculated losses as follows:

$$\alpha = \alpha_1 + \alpha_2 + \alpha_3.$$

In this embodiment, a pair of ribbon type optical fibers each having four single-mode optical fibers were used. The core fibers of this pair of optical fibers were fusion-spliced together and the splice losses were

measured using the power monitor method. From the acquired data, the total splice loss was measured based on the measuring method according to this invention.

For measurement of this splice loss, an apparatus for monitoring the spliced portion of the optical fiber from two directions was used to observe the external deviation amount of the spliced portion from two directions (X and Y directions) normal to the axes (i.e., Z axes) of the optical fibers. In this embodiment, the amount of the axial deviation was measured immediately after heat was applied for fusion-splicing the fibers and was again measured after the heat treatment was completed, the difference Y between these two deviation amounts was attained, and the splice loss was measured from this difference Y. According to this embodiment, the above measurement was executed for both of the case where fibers having their ends cleaved by the proper cutter were fusion-spliced and the case where fibers having their ends cleaved by an intentionally unadjusted cutter. The reason for using those fibers with their ends cleaved by the unadjusted cutter is to generate many defective spliced portions and to effectively evaluate the measuring function of this invention.

As described above, if the angle between the fiber ends is large, the in-phase core distortion would occur. With this in mind, therefore, we acquired data of the relation between the angle between the fiber ends and the splice loss - estimated loss. The results are shown in Fig. 4 from which it should be understood that with the angle greater than 5 degrees, an increase in loss difference between measured splice loss and calculated loss becomes large, so does the error. Accordingly, for those fibers having an angle of more than 5 degrees between their ends, the fusion-splicing was not carried out and no data was acquired.

Fig. 5 is a histogram of the splice losses (measured by the power monitor method) of the spliced portions formed by fusion-splicing those optical fibers having their ends cleaved by the proper cutter. Fig. 6 is a histogram of the errors (estimated errors) of the estimated losses (total) with respect to the splice losses. The relation between the splice losses and the estimated losses is illustrated in Fig. 7. From these, good results were attained with the average of the estimated error being -0.002 dB and the standard deviation being 0.04 dB.

Fig. 8 is a histogram of the splice losses of the spliced portions formed by fusion-splicing those optical fibers having their ends cleaved by the unadjusted cutter. Fig. 9 is a histogram of the estimated errors of this case, and Fig. 10 illustrates the relation between the splice losses and the estimated losses. In this case, the average of the estimated error was 0.013 dB and the standard deviation was 0.04 dB, about the same values as those obtained in the former case involving the optical fibers with their ends cleaved by the proper cutter.

These results are illustrated in Tables 1 and 2 below, the former illustrating the data associated with the optical fibers with their ends cleaved by the proper cutter and the latter illustrating the data associated with the fibers with their ends cleaved by the unadjusted cutter.

From these tables, it should be noted that, for either cutter, the average splice loss is less than 0.1 dB and the splice failure ratio is 2 % for the proper cutter, making this embodiment sufficiently practical (see particularly Figs. 5 and 8).

Referring to Fig. 11, ribbon type optical fibers 1_1 and 1_2 each have a tape-like shape, and each comprise four parallel single-mode optical fibers 11 to 14. Protection jackets 20 are removed from those ends of the parallel fibers 11-14 of the optical fibers 1_1 and 1_2, which are to be fusion-spliced.

To fusion-splice optical fibers 1_1 and 1_2, jacketed portion 20 of each optical fiber is clamped by adapter 21, as shown in Fig. 12. Adapter 21 is accommodated in a guide groove (not shown) formed in the body (not shown) of the apparatus. Optical fibers 11-14 of each of optical fibers 1_1 and 1_2 are set in V-grooves (not shown) of V-groove block 22 mounted on the apparatus body, so that the end faces of optical fibers 11-14 of one optical fiber 1_1 are opposed to the end faces of optical fibers 11-14 of the other optical fiber 1_2. Adapters 21 are then moved in Z direction (Fig. 12), so that an initial interval is set between the optical fibers 11-14 of optical fiber 1_1 and the optical fibers 11-14 of optical fiber 1_2, while monitoring the ends of the optical fibers 11-14 of the optical fibers 1_1 and 1_2 by monitoring method using microscope 23, TV (television) camera 24, and TV monitor 25 (Fig. 12). Then, heat of an arc discharge is applied via discharge electrodes 26_1 and 26_2 to the ends of the optical fibers 11-14 of optical fibers 1_1 and 1_2 to round the fiber ends so that the fiber ends may be strongly fusion-spliced at the following spliced step. Thereafter, heat of an arc discharge is applied via discharge electrodes 26_1 and 26_2 to the ends of the optical fibers 11-14 of optical fibers 1_1 and 1_2 (Fig. 12), while the optical fibers 11-14 of the optical fibers 1_1 and 1_2 are moved toward. Immediately after heat is applied to the optical fibers 11-14, the amount of the axial deviation Dx1 beween the optical fibers 11-14 of one optical fibers 1_1 and the optical fibers 11-14 of the other optical fibers 1_2 are measured, by monitoring the X images of the optical fibers 11-14 using microscope 23, TV camera 24, and TV monitor 25. Thereafter, while further applying an arc to the ends of the optical portions 11-14, adapters 21 are further moved toward in Z direction and abutted against each other, so that the optical fibers 11-14 are completely fusion-spliced. After the optical fibers 11-14 are completely fusion-spliced, that is, the heat treatment is completed, the amount of the axial deviation Dx2 between the optical fibers 11-14 of one optical fibers 1_1 and the optical fibers 11-14 of the other optical fibers 1_2 is measured, by monitoring the X images of the optical fibers 11-14 using microscope 23, TV camera 24,

and TV monitor 25. In substantially the same manner, deviations Dy1 and Dy2 in Y images corresponding to deviations Dx1 and Dx2 are measured. By performing $\sqrt{Dx1^2 + Dy1^2}$, deviation D1 which is immediatly after heat is applied can be obtained. By performing $\sqrt{Dx2^2 + Dy2^2}$, deviation D2 which is after the fibers are completely spliced can be obtained. Thereafter, the difference between deviations D1 and D2 are calculated to provide a core distortion of the fibers.

Deviations Dx1 and Dy1 may be measured prior to applying an arc to the fibers.

In order to obtain the X and Y image of the optical fibers 11-14 by the picked up system, illuminating lights $\ell 1$ and $\ell 2$ (Fig. 13) are emitted from light source 27 (Fig. 12). Lights $\ell 1$ and $\ell 2$ are directed in a direction shifted by 45° from the normal direction of a plane which is formed by the optical fibers 11-14. Illuminating light $\ell 1$ is reflected by reflecting mirror 28 and then passed through optical fibers 11-14. Illuminating light $\ell 2$ is passed through optical fibers 11-14 and then reflected by reflecting mirror 28. The reflected light $\ell 1$ is picked up by TV camera 24 through microscope 23 and transferred to TV monitor 25 to display images X of the optical fibers 11-12 on the monitor screen. In order to picked up illuminating light $\ell 2$, microscope 23 and TV camera 24 are slightly moved. The reflected light $\ell 2$ is picked up by TV camera 24 through microscope 23 and transferred to TV monitor 25 to display images Y of the optical fibers 11-12 on the monitor screen.

Referring to Fig. 14, single type optical fibers 10_1 and 10_2 are shown, together with a fusion splicing apparatus. Protection jackets are removed for fusion-splice. Optical fibers 1_1 and 1_2 are supported in V-grooves of V-groove members 32_1 and 32_2 to oppose each other in the Z direction (Fig. 14). Thereafter, an abutment rod or a stopper (not shown) is located between optical fibers 1_1 and 1_2, and optical portions 1_1 and 1_2 are moved closed to each other in the Z direction until fiber portions 1_1 and 1_2 are brought into contact with the stopper, thereby setting an initial distance between fiber portions 1_1 and 1_2. Thereafter, stopper is removed. Then, heat of an arc discharge is applied via discharge electrodes 26_1 and 26_2 to the ends of the optical fibers 1_1 and 1_2 to round the fiber ends so that the fiber ends may be strongly fusion-spliced at the following spliced step. Thereafter, heat of an arc discharge is applied via discharge electrode 26_1 and 26_2 to the ends of the optical fibers 1_1 and 1_2, while the optical fibers are moved toward. Immediately after heat is applied to the optical fibers 1_1 and 1_2 the amount of the axial deviation Dx1 between the optical fibers 1_1 and 1_2 is measured, by monitoring the X image of the optical fibers 1_1 and 1_2 using microscope 23, TV camera 24, and TV monitor 25. After, while further applying an arc to the ends of the optical fibers 1_1 and 1_2, the optical fibers are further moved toward in the Z direction and abutted against each other, so that optical fibers are completely fusion-spliced. After the optical fibers 1_1 and 1_2 are completely fusion-spliced, that is, the heat treatment is completed, the amount of the axial deviation Dx2 between the optical fibers 1_1 and 1_2 is measured, by monitoring the X image of the optical fibers 1_1 and 1_2 using microscope 23, TV camera 24, and TV monitor 25.

In substantially the same manner, deviations Dy1 and Dy2 in Y image are measured. The manner in which a core distortion of the fibers are measured is substantially the same in the ribbon type fibers. Therefore, the description thereof is omitted.

Deviations Dx1 and Dy1 may be measured prior to applying an arc to the fibers.

In this embodiment, two light sources 32 and 34 are used to emit X-direction light Lxx and Y-direction light Lxy, respectively. Light Lxx is passed through the fiber ends in X-direction and picked up through microscope 23 by TV camera 24. Light Lxy is first passed through the fiber ends in Y-direction, then reflected by reflecting mirror 28, and finally picked up through microscope 23 by TV camera 24. TV monitor 25 displays the X and Y images of the fiber ends on the monitor screen based on the picked up lights by TV camera 24.

According to this embodiment, the estimated losses originated from the opposite-phase core distortion were attained from the difference between the amounts of axial deviation immediately after the fusion-splicing and upon completion of the heat treatment. With a slight error allowed, however, it is possible to measure the amount of axial deviation before the heat application and use this value. In other words, although the amount of the axes of the fibers deviated by the pressing force applied thereto at the time of fusion-splicing becomes an error in this case, it is possible to eliminate the measurement immediately after the heat application.

According to the fiber splice loss estimating method of this invention, the splice loss originated from the opposite-phase core distortion and the total splice loss can be measured with a high accuracy by observing the outline of the spliced section. This method can ensure easy detection of defective spliced portions, and is therefore suitable for field works where the fibers are installed. In addition, the use of this method in fusion-splicing ribbon type optical fibers together can further improve the efficiency of the splicing works.

TABLE 1 (Data About Optical Fibers With Their Cleaved by Proper Cutter)

		Number of Fusion-spliced Splice Portions	Number of Splice Portions (Excluding Those At Which In-phase Core Distortion Has Occurred)
Number of Fibers		506	496
Splice Loss (dB)	Average	0.076	0.049
	Standard Deviation	0.361	0.051
	Maximum	6.86	0.51
Estimated Loss (dB)	Average	-	-0.002
	Standard Deviation	-	0.042
	Maximum	-	0.35

TABLE 2 (Data About Optical Fibers With Their Cleaved by Unadjusted Cutter)

		Number of Fusion-spliced Splice Portions	Number of Splice Portions (Excluding Those At Which In-phase Core Distortion Has Occurred)
Number of Fibers		160	122
Splice Loss (dB)	Average	0.168	0.079
	Standard Deviation	0.423	0.069
	Maximum	3.68	0.52
Estimated Loss (dB)	Average	-	0.013
	Standard Deviation	-	0.059
	Maximum	-	0.20

Claims

1. A method for estimating a splice loss of a spliced portion of an optical fiber formed by fusion-splicing a pair of optical fibers (1_1, 1_2) through heat treatment, which method is characterized by comprising steps of:

detecting respective axial deviations Dx1 and Dy1 prior to or immediately after heating a pair of optical fibers (1_1, 1_2);

measuring a composite axial deviation D1 by performing $\sqrt{Dx1^2 + Dy1^2}$;

detecting respective axial deviations Dx2 and Dy2 upon completion of heat treatment to said optical fibers;

measuring a composite axial deviation D2 by performing $\sqrt{Dx2^2 + Dy2^2}$;

measuring a difference between said composite axial deviations D1 and D2 to provide an opposite-phase core distortion Y; and

measuring a splice loss α 3 based on said opposite-phase core distortion Y, by using a predetermined relationship obtained from experimental data of the opposite-phase core distortion Y and the splice loss α 3.

2. A method for estimating a splice loss of a spliced portion of an optical fiber, according to claim 1, characterized by further comprising a step of:

detecting an angular deviation θ upon completion of heat treatment of said optical fibers;

measuring a splice loss α 2 based on said angular deviation θ or by using a predetermined relationship obtained from experimental data of the angular deviation θ and the splice loss α 2;

measuring a splice loss α 1 based on said composite axial deviation D2 by using a predetermined relationship obtained from experimental data of the composite axial deviation D2 and α 1; and

measuring an entire splice loss αo by summing all of said splice losses α 1 + α 2 + α 3.

3. A method of estimating a splice loss of a spliced portion of an optical fiber, according to claim 1, characterized in that said predetermined relationship used for measuring the splice loss α 3 is expressed by an equation of α 3 = 0.01484Y.

4. A method of estimating a splice loss of a spliced portion of an optical fiber, according to claim 2, characterized in that,

said predetermined relationship used for measuring the splice loss α 3 is expressed by an equation of

$$\alpha\ 3 = 0.01484Y,$$

said predetermined relationship used for measuring the splice loss α 2 is expressed by an equation of

$$\alpha\ 2 = 10 \log [\exp\{-(\pi^2 n_2 w/180\ \lambda)^2 \theta^2\}], \text{ and}$$

where

n2 is a refractive index of a core of said optical fiber,

W is a spot size, and

λ is the wavelength of light,

and

said predetermined relationship used for measuring the splice loss α 1 is expressed by an equation of

$$\alpha\ 1 = 4.34 \times (D2/W)^2$$

5. A method of estimating a splice loss of a spliced portion of an optical fiber, according to any one of the preceding claims, characterized in that, said pair of optical fibers ate a plurality of ribbon type optical fibers.

Patentansprüche

1. Verfahren zur Bestimmung eines Spleißverlustes eines gespleißten Abschnittes einer optischen Faser, die durch einen Schmelzspleißvorgang eines Paares optischer Faser (11, 12) mittels einer Wärmebehandlung hergestellt wird, wobei das Verfahren durch folgende Verfahrensschritte gekennzeichnet ist:

Erfassen jeweiliger axialer Abweichungen Dx1 und Dy1 vor oder unmittelbar nach dem Erwärmen eines Paares optischer Fasern (1_1, 1_2);

Messen einer zusammengesetzten axialen Abweichung D1 durch Ausführen von $\sqrt{Dx1^2 + Dy1^2}$

Erfassen jeweiliger axialer Abweichungen Dx2 und DY2 bei der Vollendung der Wärmebehandlung der optischen Fasern;

Messen einer zusammengesetzten axialen Abweichung D2 durch Ausführen von $\sqrt{Dx2^2 + Dy2^2}$;

Messen einer Differenz zwischen den zusammengesetzten axialen Abweichungen D1 und D2, um eine gegenphasige Kernverwindung Y zu bestimmen; und

Messen eines Spleißverlustes α 3 auf der Grundlage der gegenphasigen Kernverwindung Y durch Ver-

wenden einer vorbestimmten Beziehung, die aus experimentellen Daten der gegenphasigen Kernverwindung Y und des Spleißverlustes α 3 gewonnen wird.

2. Verfahren zum Bestimmen eines Spleißverlustes eines gespleißten Abschnittes einer optischen Faser gemäß Anspruch 1, gekennzeichnet durch folgende weitere Verfahrensschritte:

Erfassen einer Winkelabweichung θ bei der Vollendung der Wärmebehandlung der optischen Fasern;

Messen eines Spleißverlustes α 2 auf der Basis der Winkelabweichung θ oder durch Benutzung einer vorbestimmten Beziehung, die aus experimentellen Daten der Winkelabweichung θ und des Spleißverlustes α 2 gewonnen wird;

Messen eines Spleißverlustes α 1 auf der Basis der zusammengesetzten axialen Abweichung D2 durch Verwendung einer vorbestimmten Beziehung, die aus experimentellen Daten der zusammengesetzten axialen Abweichung D2 und α 1 gewonnen wird; und

Messen eines gesamten Spleißverlustes α o durch Aufsummieren aller Spleißverluste $\alpha 1 + \alpha 2 + \alpha 3$.

3. Verfahren zum Bestimmen eines Spleißverlustes eines gespleißten Abschnittes einer optischen Faser gemäß Anspruch 1, dadurch gekennzeichnet, daß die vorbestimmte Beziehung, die zum Messen des Spleißverlustes α 3 benutzt wird, durch eine Gleichung gemäß α 3 = 0,01484Y ausgedrückt wird.

4. Verfahren zum Bestimmen eines Spleißverlustes eines gespleißten Abschnittes einer optischen Faser nach Anspruch 2, dadurch gekennzeichnet, daß

die vorbestimmte Beziehung, die zum Messen des Spleißverlustes α 3 benutzt wird, durch die Gleichung

$$\alpha\ 3 = 0{,}01484Y$$

ausgedrückt wird, daß die vorbestimmte Beziehung, die zum Messen des Spleißveriustes α 2 benutzt wird, durch die Gleichung

$$\alpha\ 2 = 10 \log [\exp\{-(\pi^2 n_2 w/180\ \lambda)^2 \theta^2\}], \text{ und}$$

wobei

n2 ein Brechungsindex eines Kerns der optischen Faser ist,

W eine Punktgröße, und

λ die Wellenlänge des Lichtes ist,

und

daß die vorbestimmte Beziehung, die zum Messen des Spleißverlustes α 1 verwendet wird, durch die Gleichung

$$\alpha\ 1 = 4{,}34 \times (D2/W)^2$$

ausgedrückt wird.

5. Verfahren zum Bestimmen des Spleißverlustes eines gespleißten Abschnittes einer optischen Faser nach einem der vorangehenden Ansprüche, dadurch gekennzeichnet, daß das paar optischer Fasern eine Mehrzahl von bandartigen optischen Fasern ist.

Revendications

1. Procédé pour estimer une perte optique de raccordement dans une partie raccordée d'une fibre optique formée par un raccordementfusion d'une paire de fibres optiques (1_1, 1_2) à l'aide d'un traitement thermique, ce procédé étant caractérisé par le fait qu'il comprend les étapes de :

détection des écarts axiaux respectifs Dx1 et Dy1 avant ou immédiatement après le chauffage d'une paire de fibres optiques (1_1, 1_2); mesure d'un écart axial composite D1 par calcul de $\sqrt{Dx1D^2 + Dy1^2}$;

détection des écarts axiaux respectifs Dx2 et Dy2 à la fin du traitement thermique appliqué aux fibres optiques;

mesure d'un écart axial composite D2 par calcul de $\sqrt{Dx2^2 + Dy2^2}$;

mesure de la différence entre les écarts axiaux composites D1 et D2 pour obtenir une valeur Y de déformation de coeur en opposition de phase; et

à mesurer une perte optique de raccordement α 3 basé sur ladite valeur y de déformation de coeur en opposition de phase par utilisation d'une relation prédéterminée obtenue à partir de données expérimentales relatives à la valeur y de déformation de coeur en opposition de phase et à la perte par raccordement α 3.

2. Procédé pour estimer une perte optique de raccordement d'une partie raccordée d'une fibre optique selon la revendication 1, caractérisé en ce qu'il comprend en outre les étapes de :

détection d'un écart angulaire Y à la fin du traitement thermique des fibres optiques;

mesure d'une perte optique de raccordement a 2 basée sur l'écart angulaire θ ou par utilisation d'une relation prédéterminée obtenue à partir de données expérimentales relatives à l'écart angulaire θ et à la perte optique de raccordement α 2;

mesure d'une perte optique de raccordement α 1 basée sur l'écart axial composite D2 par utilisation d'une relation prédéterminée obtenue à partir d'une donnée expérimentale relative à l'écart axial composition D2 et α 1; et

mesure d'une perte optique de raccordement α o totale par sommation de toutes les pertes optiques de raccordement α 1 +α 2+ α 3.

3. Procédé pour estimer une perte optique de raccordement d'une partie raccordée d'une fibre optique selon la revendication 1, caractérisé en ce que la relation prédéterminée utilisée pour mesurer la perte optique de raccordement a 3 est exprimée par l'équation α 3 = 0,01484Y.

4. Procédé pour estimer une perte optique de raccordennnent d'une partie raccordée d'une fibre optique selon la revendication 2, caractérisé en ce que :

la relation prédéterminée utilisée pour mesurer la perte optique de raccordement a 3 est exprimée par l'équation :

$$\alpha\ 3 = 0{,}01484Y,$$

la relation prédéterminée utilisée pour mesurer la perte optique de raccordement a 2 est exprimée par l'équation:

$$\alpha\ 2 = 10 \log [\exp \{-\pi^2 n_2 w/180\ \lambda)^2 \theta^2\}], \text{ et}$$

où

n2 est l'indice de réfraction du noyau de la fibre optique,

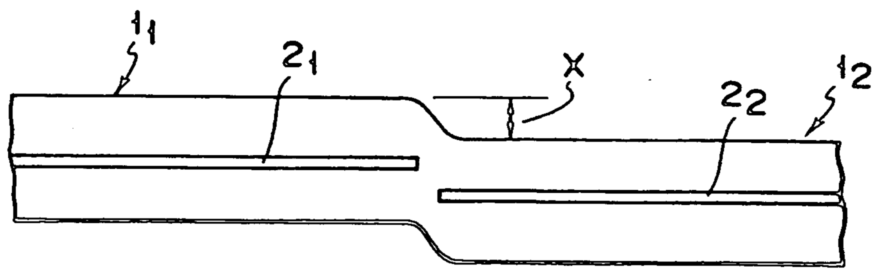
W est la dimension d'un spot, et

λ est la longueur d'onde de la lumière, et

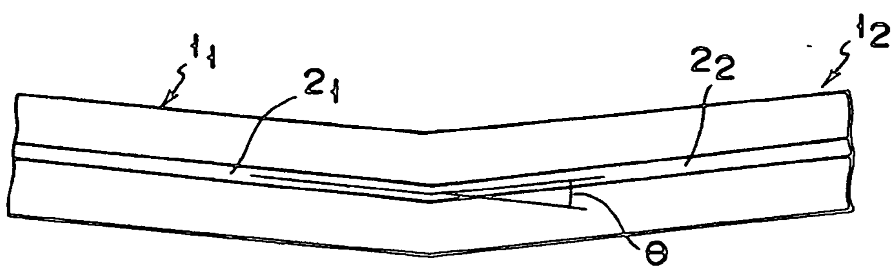
la relation prédéterminée utilisée pour mesurer la perte optique de raccordement α 1 est exprimée par l'équation :

$$\alpha\ 1 = 4,34 \times (D2/W)^2.$$

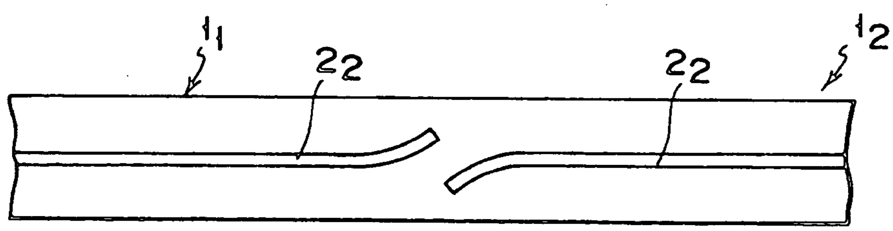
5. Procédé pour estimer la perte optique de raccordennnent d'une partie raccordée d'une fibre optique selon l'une quelconque des revendications précédentes, caractérisé en ce que la paire de fibres optiques est formée par une pluralité de fibres optiques du type ruban.



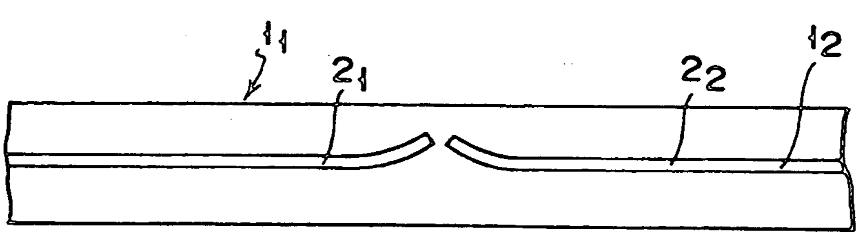
F I G. 1A



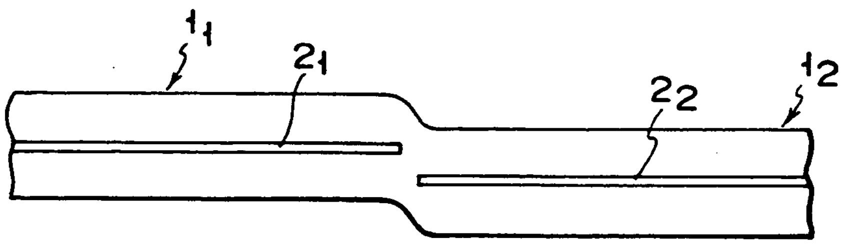
F I G. 1B



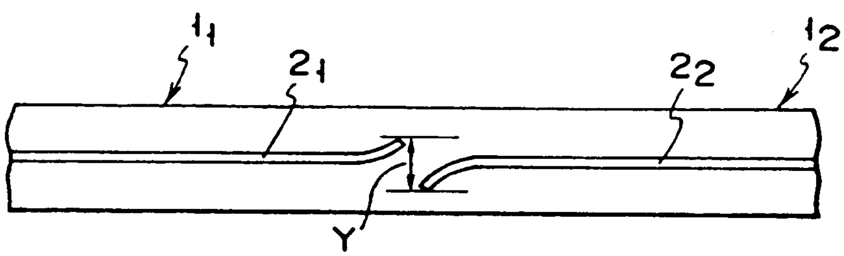
F I G. 1C



F I G. 1D



F I G. 2A



F I G. 2B

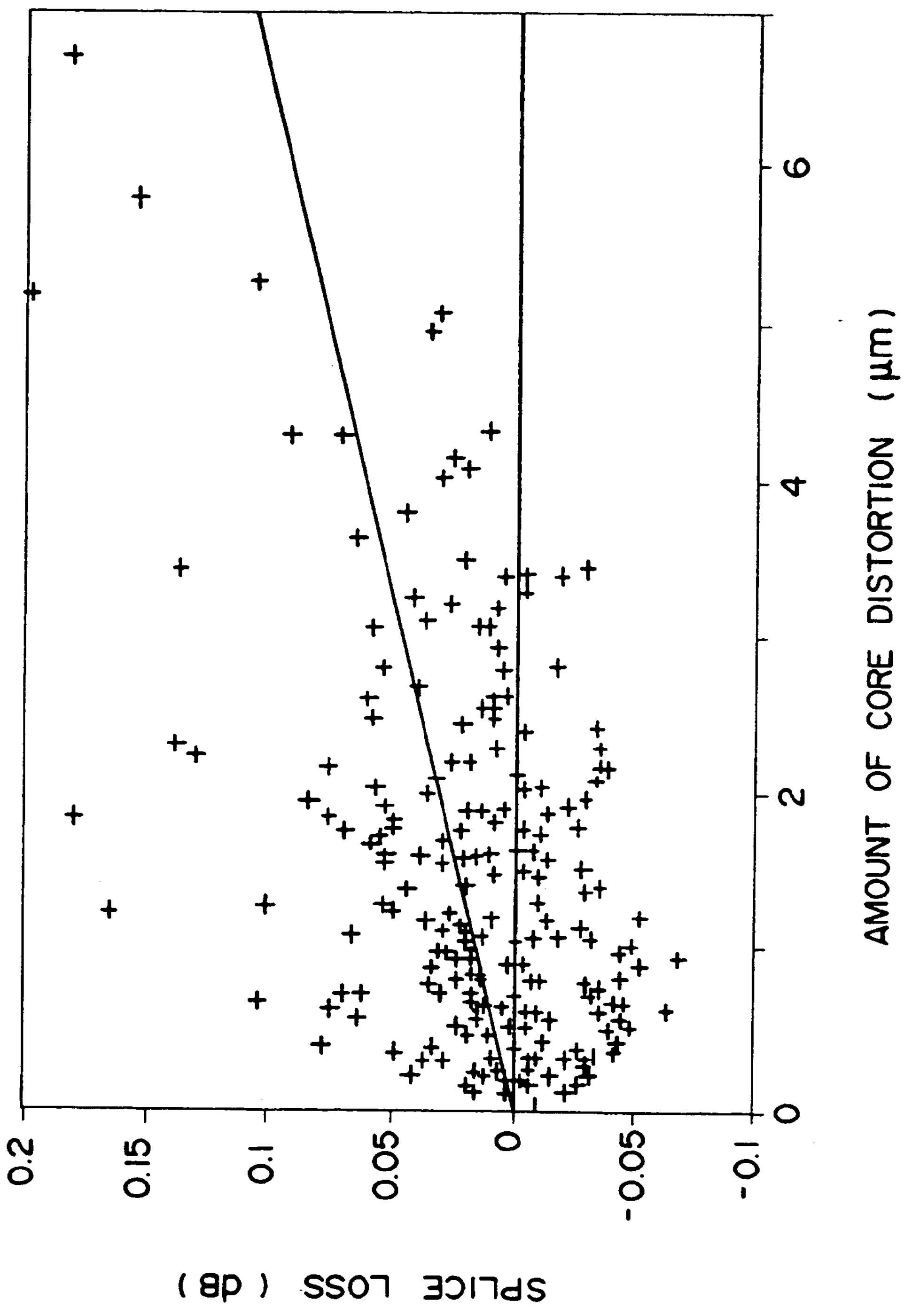

SPLICE LOSS (dB)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
0
2
4
6
AMOUNT OF CORE DISTORTION (μm)

FIG. 3

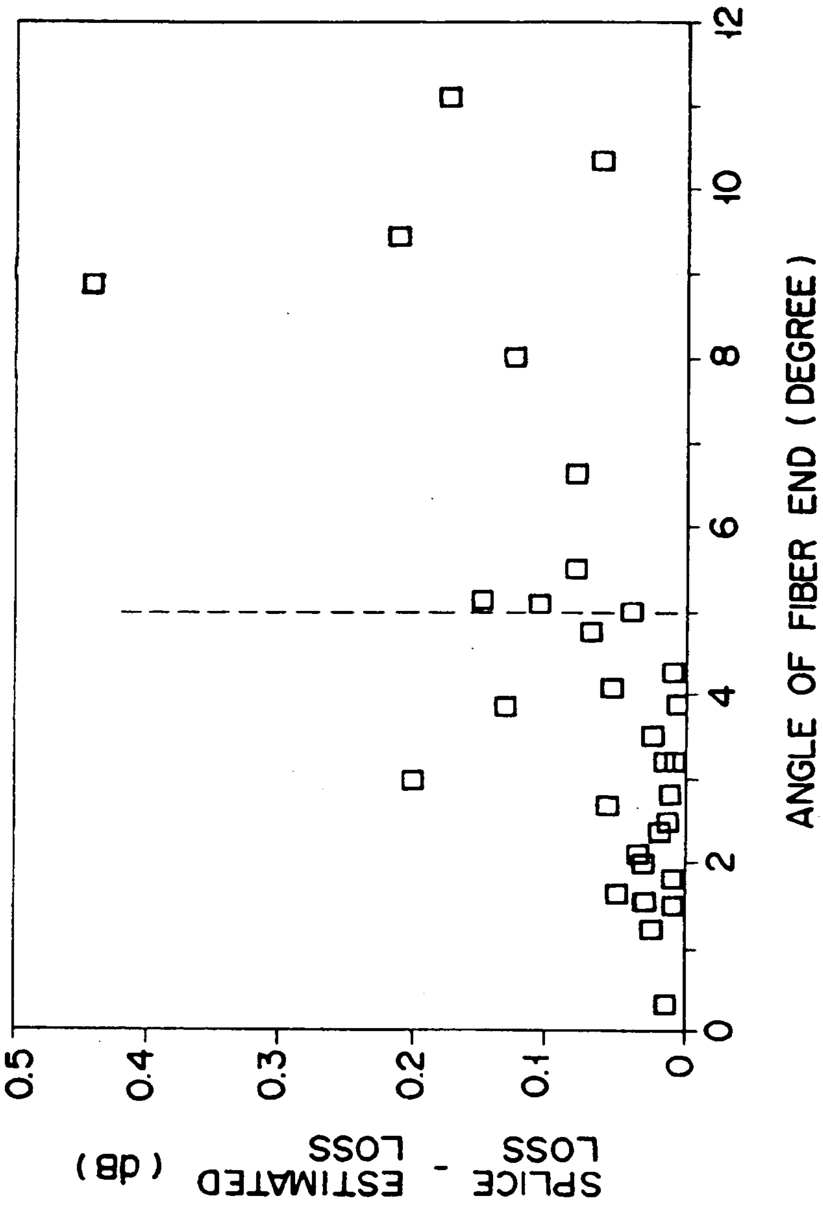

SPLICE LOSS - ESTIMATED LOSS (dB)
0.5
0.4
0.3
0.2
0.1
0
0
2
4
6
8
10
12
ANGLE OF FIBER END (DEGREE)

FIG. 4

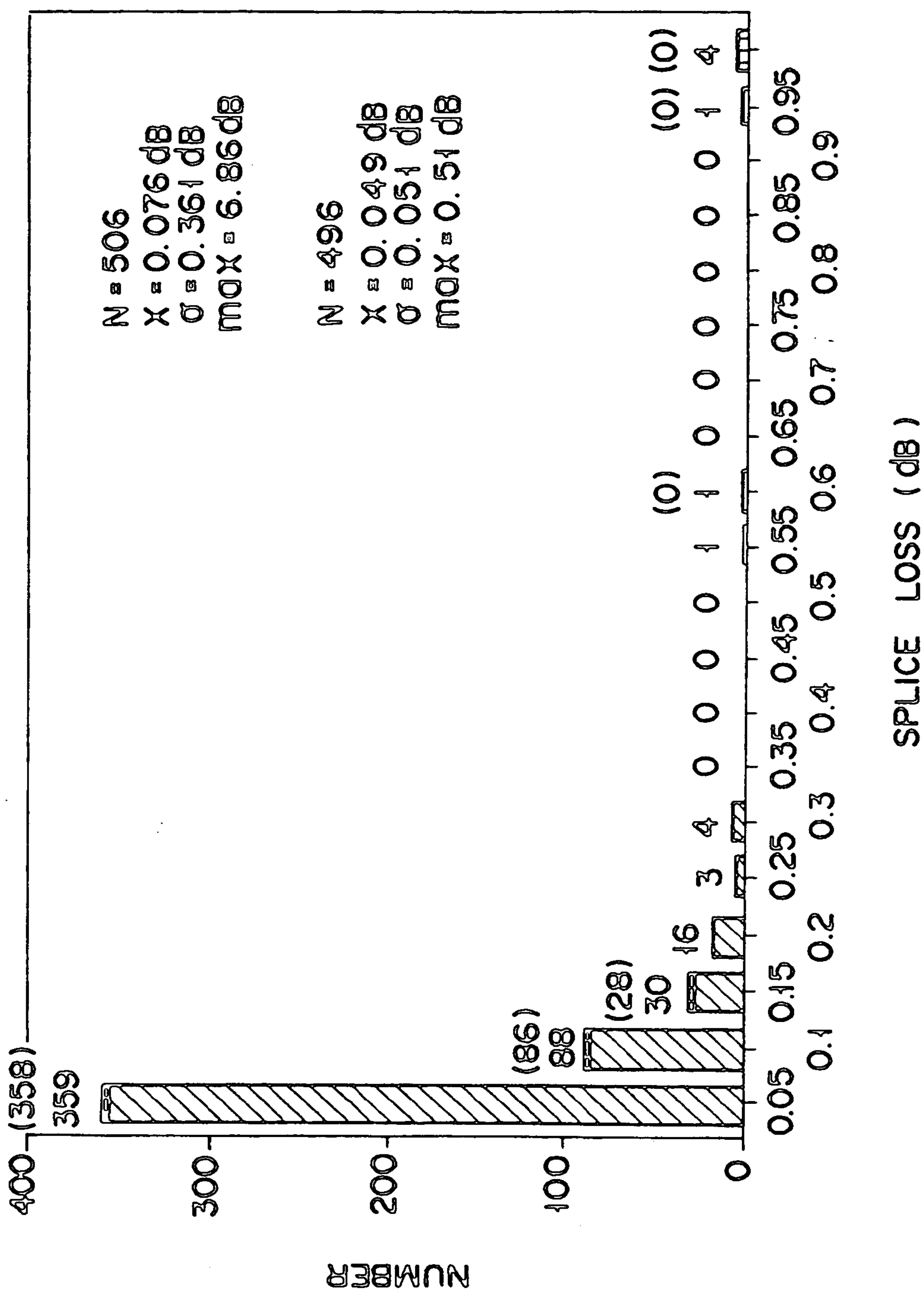
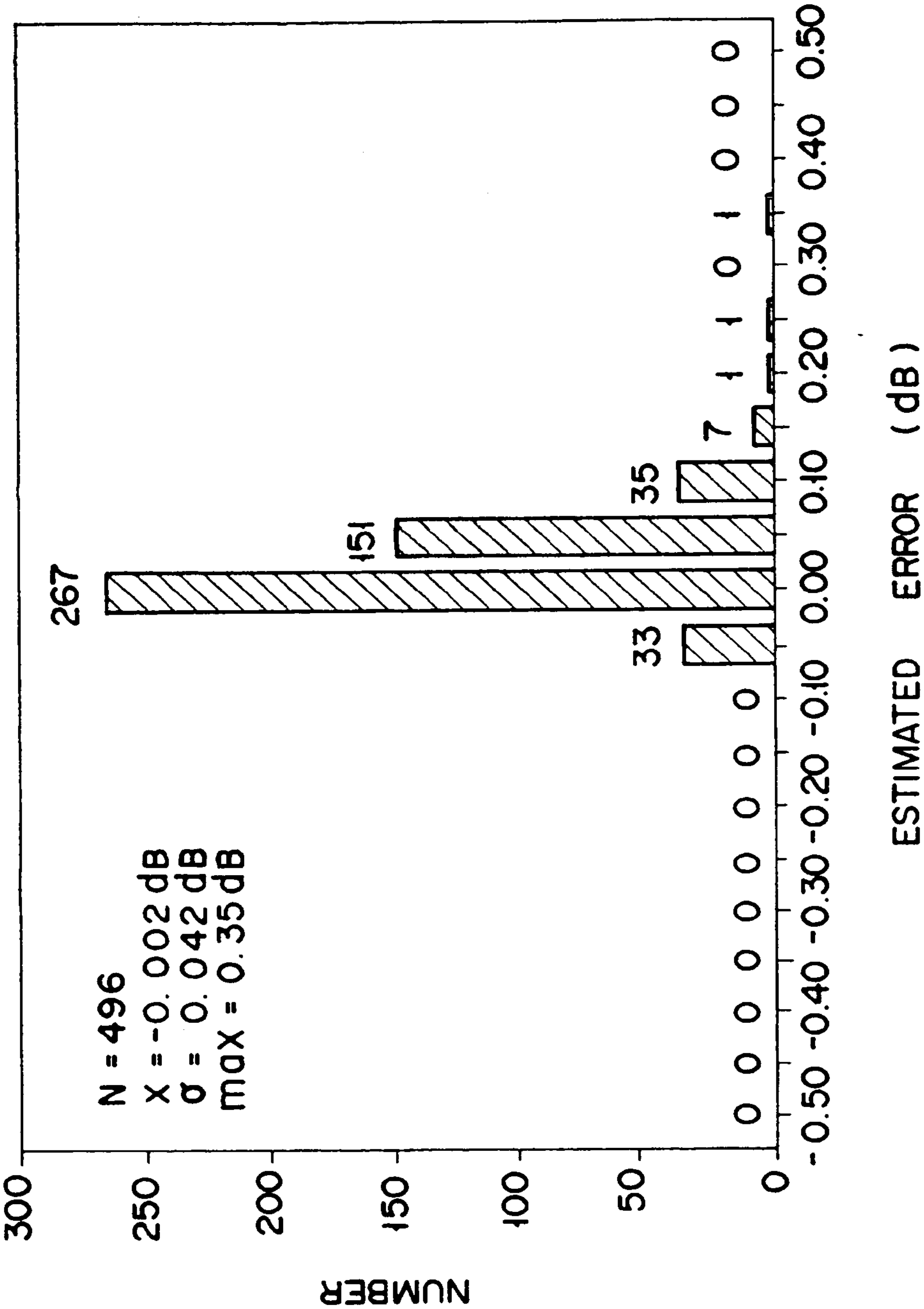
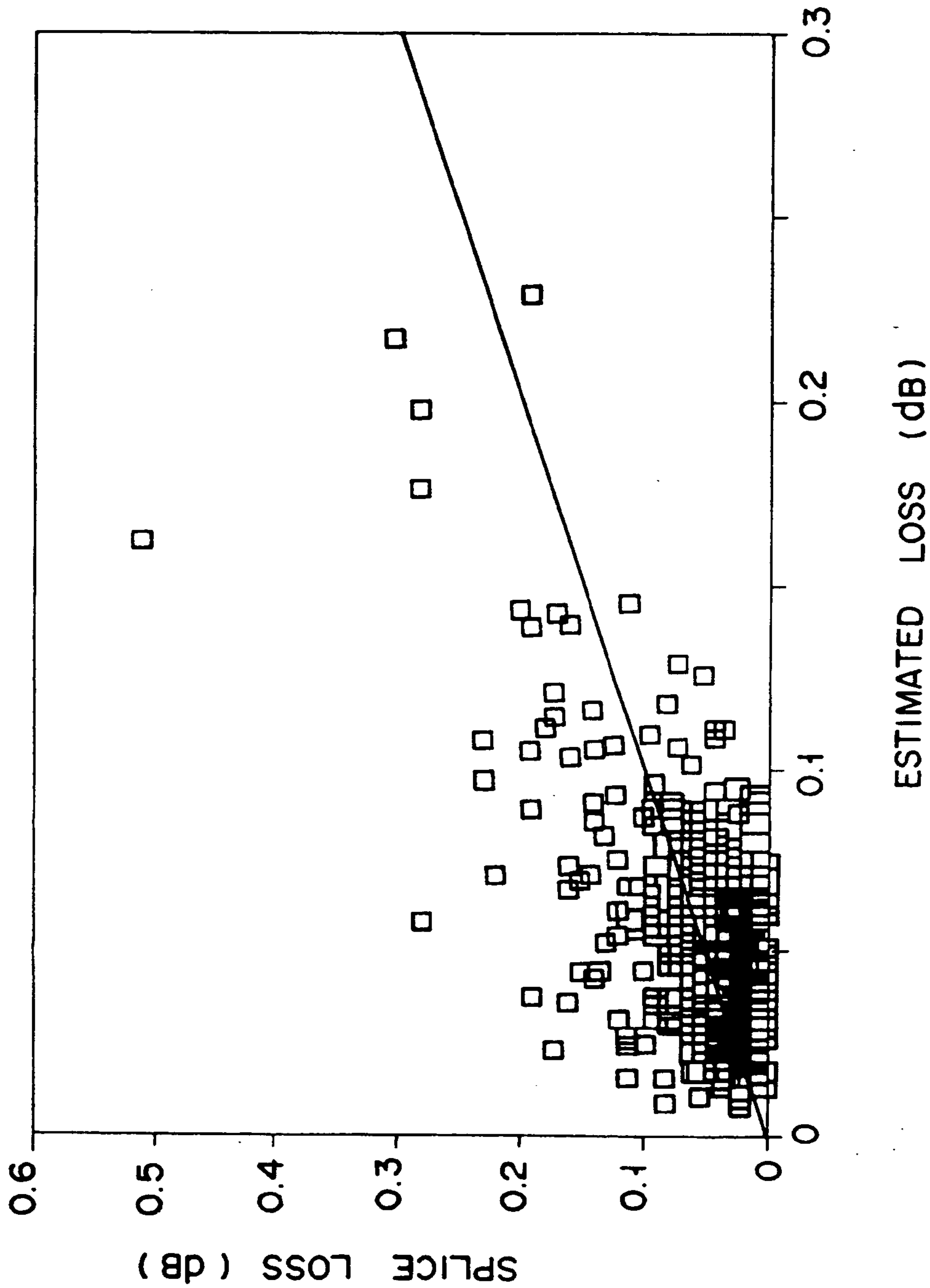

NUMBER
400
300
200
100
0
(358)
359
(86)
88
(28)
30
16
3
4
0
1
(0)
1
(0)
4
(0)
N = 506
X = 0.076 dB
σ = 0.361 dB
max = 6.86dB
N = 496
X = 0.049 dB
σ = 0.051 dB
max = 0.51 dB
0.05 0.1 0.15 0.2 0.25 0.3 0.35 0.4 0.45 0.5 0.55 0.6 0.65 0.7 0.75 0.8 0.85 0.9 0.95
SPLICE LOSS (dB)

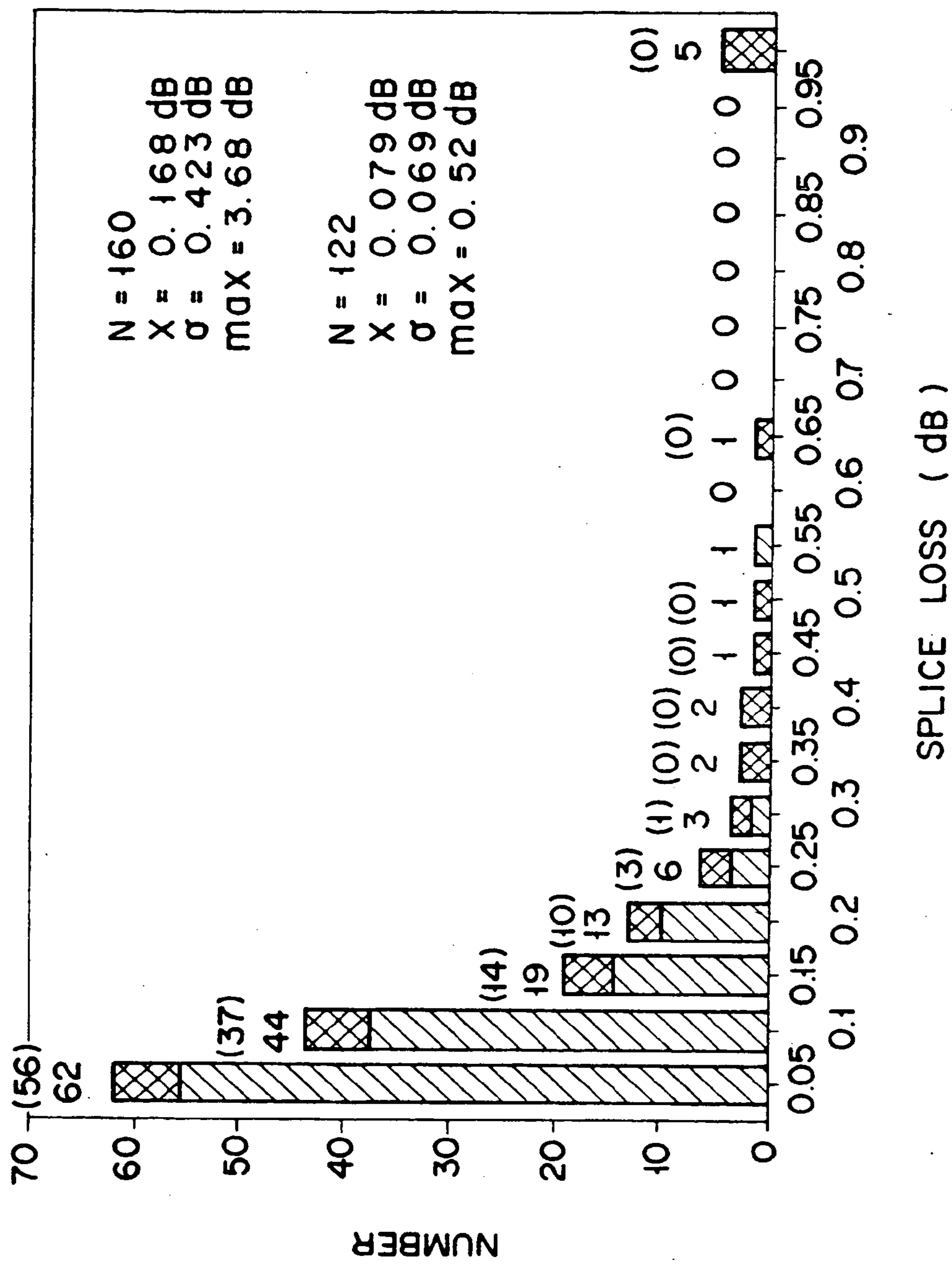
FIG. 5


N = 496
X = -0. 002 dB
σ = 0. 042 dB
max = 0. 35 dB
NUMBER
ESTIMATED ERROR (dB)
0 50 100 150 200 250 300
-0.50 -0.40 -0.30 -0.20 -0.10 0.00 0.10 0.20 0.30 0.40 0.50
0 0 0 0 0 0 0 0 33 267 151 35 7 1 1 0 1 0 0 0

F I G. 6



F I G. 7



N = 160
X = 0. 168 dB
σ = 0. 423 dB
max = 3.68 dB
N = 122
X = 0. 079 dB
σ = 0. 069 dB
max = 0. 52 dB
(56) 62
(37) 44
(14) 19
(10) 13
(3) 6
(1) 3
(0) 2
(0) 2
(0) 1
(0) 1
1
0
(0) 1
0
0
0
0
0
0
(0) 5
NUMBER
0
10
20
30
40
50
60
70
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
0.55
0.6
0.65
0.7
0.75
0.8
0.85
0.9
0.95
SPLICE LOSS (dB)

F I G. 8

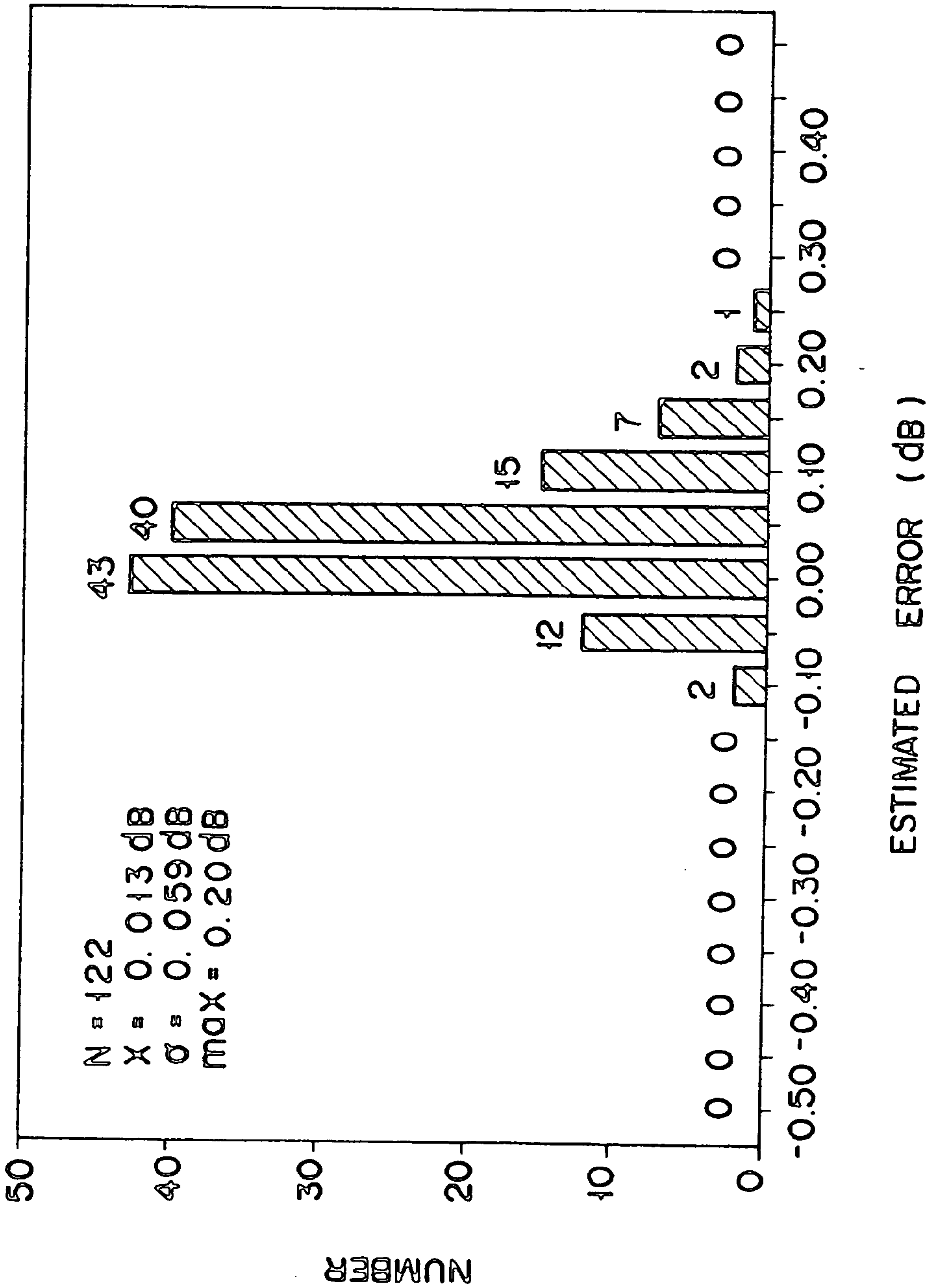

N = 122
X = 0.013 dB
σ = 0.059 dB
max = 0.20 dB
NUMBER
0
10
20
30
40
50
ESTIMATED ERROR (dB)
-0.50
-0.40
-0.30
-0.20
-0.10
0.00
0.10
0.20
0.30
0.40
0
2
12
43
40
15
7
1

FIG. 9

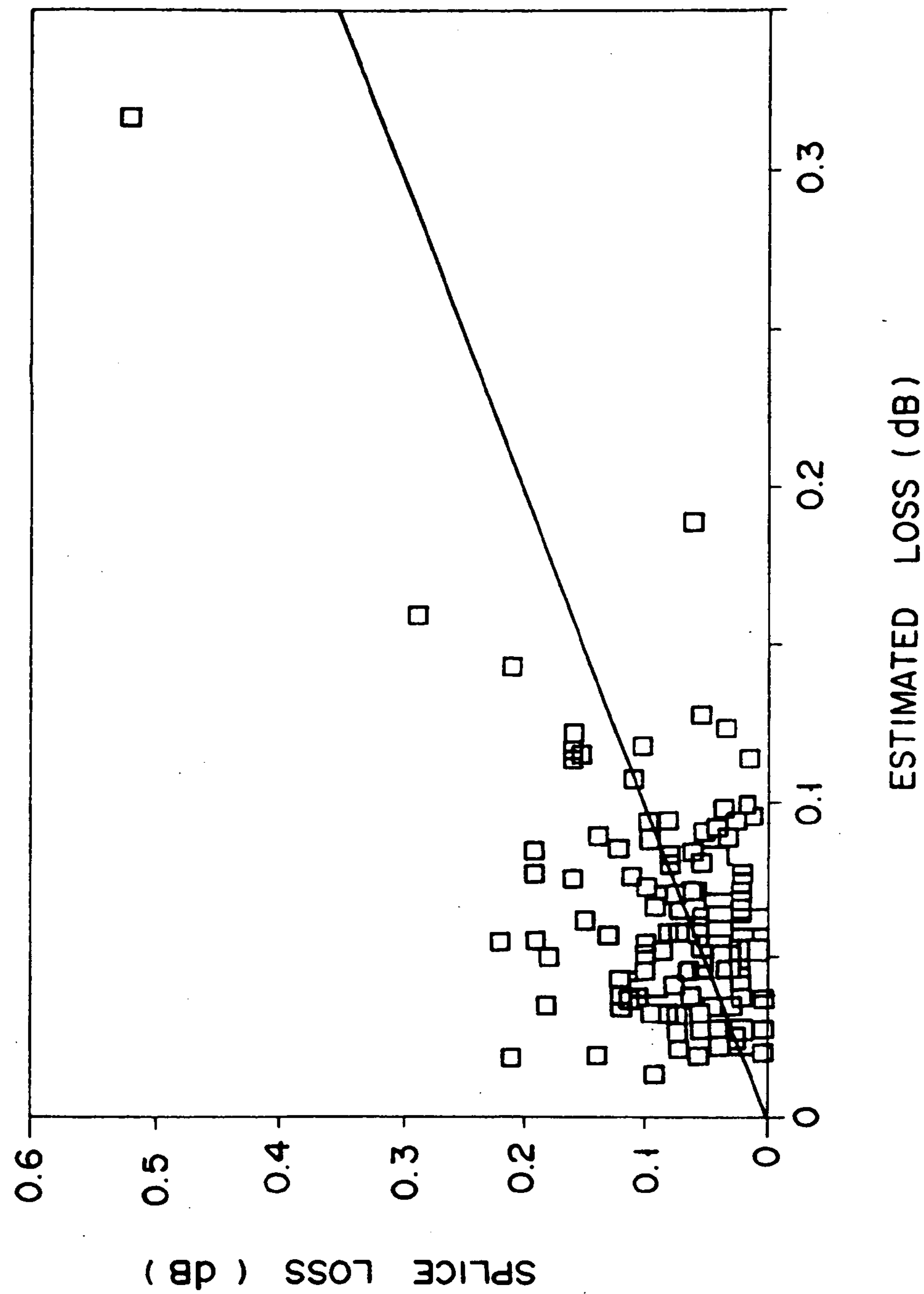


FIG. 10

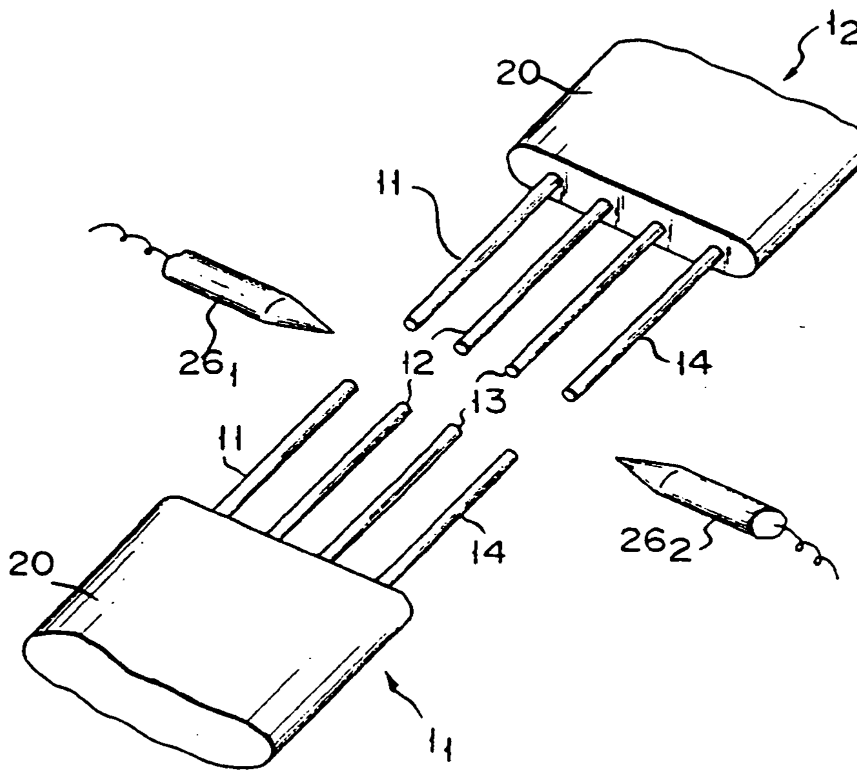


FIG. 11

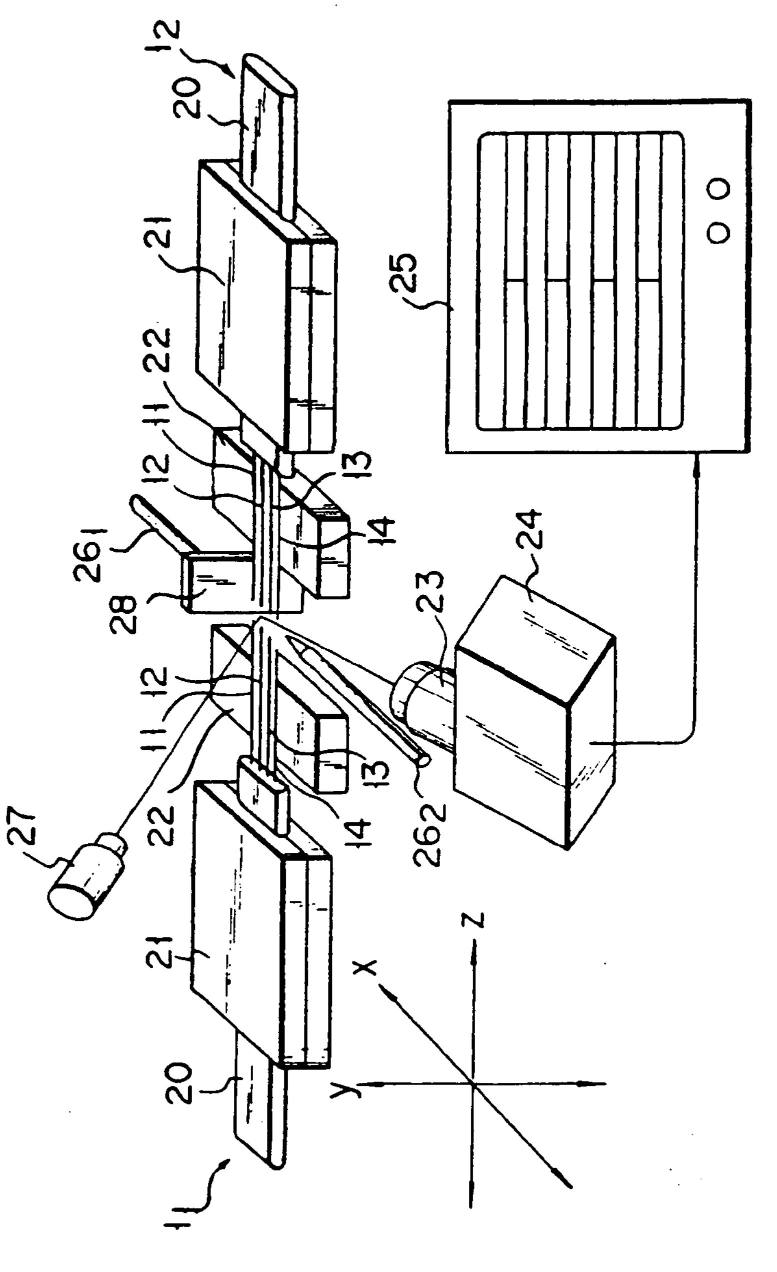


FIG. 12

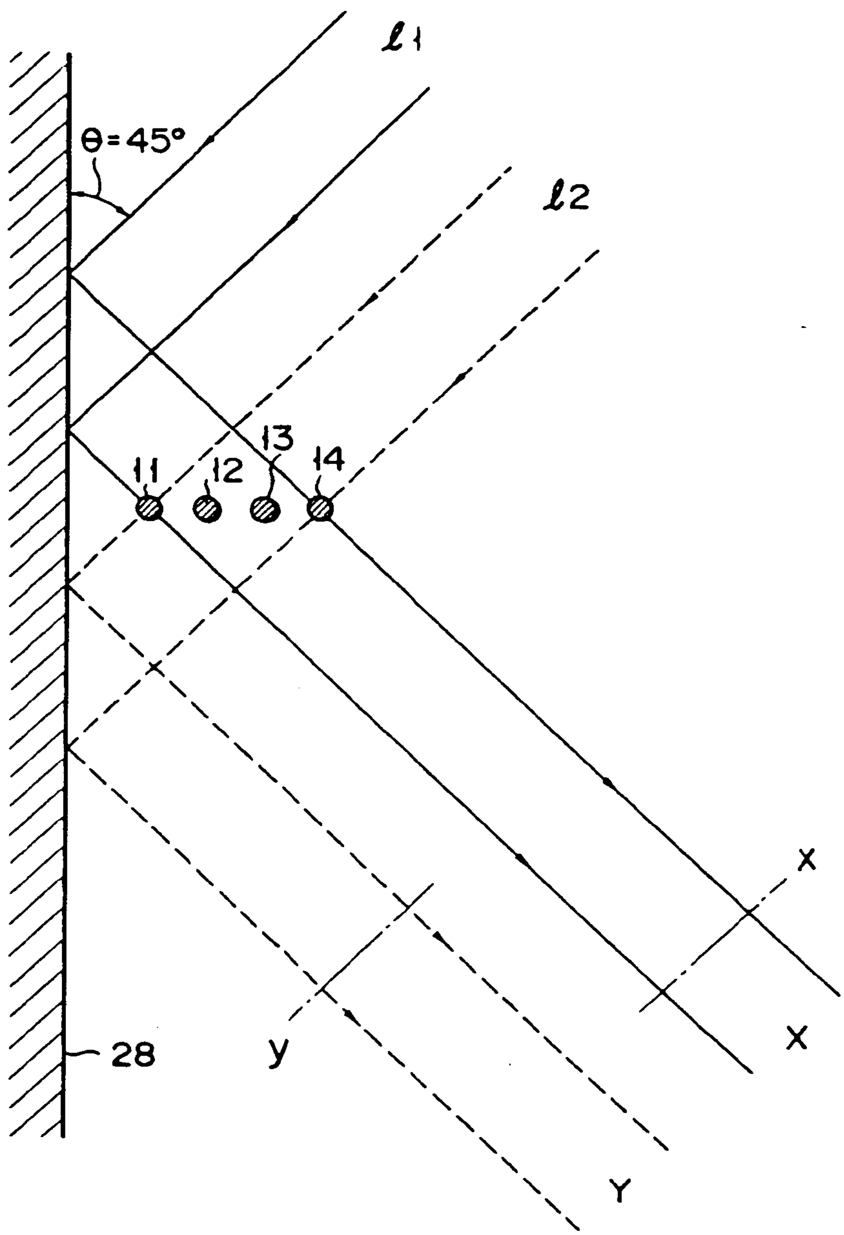


FIG. 13

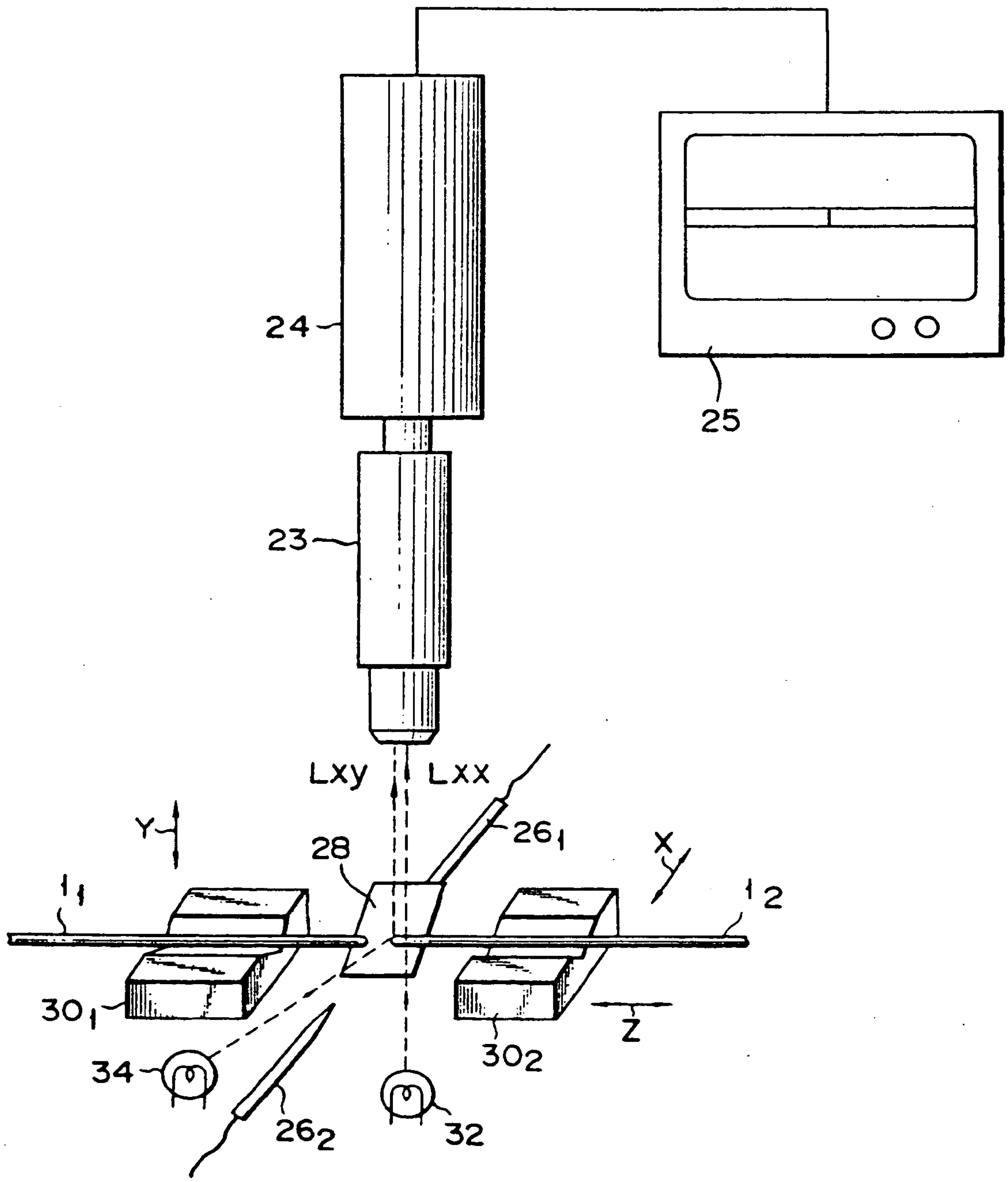


FIG. 14